



THE TERTIARY SPONGES *APHROCALLISTES* AND *EURETE* FROM WESTERN WASHINGTON AND OREGON

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ABSTRACT. Extensive collections of sponges from the Eocene to Miocene of southwestern Washington and from the Oligocene and Miocene of northwestern Oregon consist mainly of *Aphrocallistes polytretos* n. sp. This new sponge has irregular undulating to tubular walls that look like tiny-celled honeycombs because of their coarse canals. The upper cellular part of the skeleton is made of flattened hexiradiates, but the basal part is irregularly dictyonine.

The less common *Eurete goederti* n. sp., a branching zigzag tubular sponge, occurs in the Oligocene part of the Lincoln Creek Formation in southwestern Washington. Root tufts of large monaxial spicules occur in concretions with both *Eurete* and *Aphrocallistes* but may not be part of either of these sponges.

Distributions of living species of both genera suggest by analogy that the fossils lived at a depth of 300–350 meters. Most occur in coarse clastic units or in calcareous concretions with a mixed diverse fish-echinoid-sponge assemblage. This fauna may have been swept into still deeper water by pulses of high-energy currents, for most sponges and echinoids appear fragmented. Only the root tufts appear to have grown in place.

INTRODUCTION

Numerous fossil sponges have been recovered from concretions eroded out of relatively deep-water marine Eocene to Oligocene sediments near Knappton (Localities 2, 5–7, Figure 1), from Eocene limestone in a quarry near Chinook (Locality 1, Figure 1) in southwestern Washington, from Miocene concretionary beds at Astoria, and from Oligocene deposits near Yaquina (Locality 4, Figure 1) in northwestern Oregon. Near Knappton, the major locality, the sponges are apparently scattered through the formation but are most common in a zone where sponge-bearing concretions are particularly abundant. The major sponge fauna occurs presumably below beds that have produced the mollusks being studied by Ellen James Moore, of the U.S. Geological Survey, and above beds that have produced the silicified micro-mollusks (bivalves and gastropods) being studied by Carole Hickman, of the University of California Museum of Paleontology. Fossil barnacles have been described by Victor Zullo (1982) from localities both above and below the major sponge zone.

The fossils come, in large part, from concretions weathering out of a Holocene landslide block in the Lincoln Creek Formation and occur as float along the Columbia River terrace. The slump block is in the sea cliff at the head of the bay between Knappton and Grays Point. If, as Moore (personal communication, December, 1981) suggests, "there is a certain amount of stratigraphy preserved in the float from the landslide block," the sponges then are stratigraphically just below the main mollusk-bearing beds. "Because the landslide moved generally parallel with the strike of the beds, a proper stratigraphic sequence seems to have been maintained," according to Moore (personal communication, August, 1982).

The designation Lincoln Formation was initially proposed by Weaver (1912:10–12) for Oligocene beds of western Washington. Weaver (1937) later suggested retaining the name Lincoln Formation for the entire middle Oligocene of Washington. Weaver and others (1944:592) noted the Lincoln beds overlie the Keasey Formation and unconformably underlie the Miocene Astoria Formation. The Lincoln Creek Formation in the Knappton area occurs in an east-dipping homocline, west of outcrops of the Astoria Formation, in the Portuguese Point–Grays Point area west of Frankfort, Washington (Wells, 1979).

The name Lincoln Creek Formation was proposed by Beikman and others (1967) to replace the Lincoln Formation, which has been preempted several times. In the type area, the formation consists of 700–3000 m (2000–9000 feet) of clastic rocks of predominantly Oligocene age. Lincoln Creek beds unconformably overlap Eocene and older units near Oligocene paleotopographic high areas but rest conformably on Eocene beds within the basins. The Lincoln Creek Formation is overlain by the Astoria (?) Formation in the type region. Molluscan and foraminiferal correlations suggest that the Lincoln Creek Formation ranges from the Late Eocene

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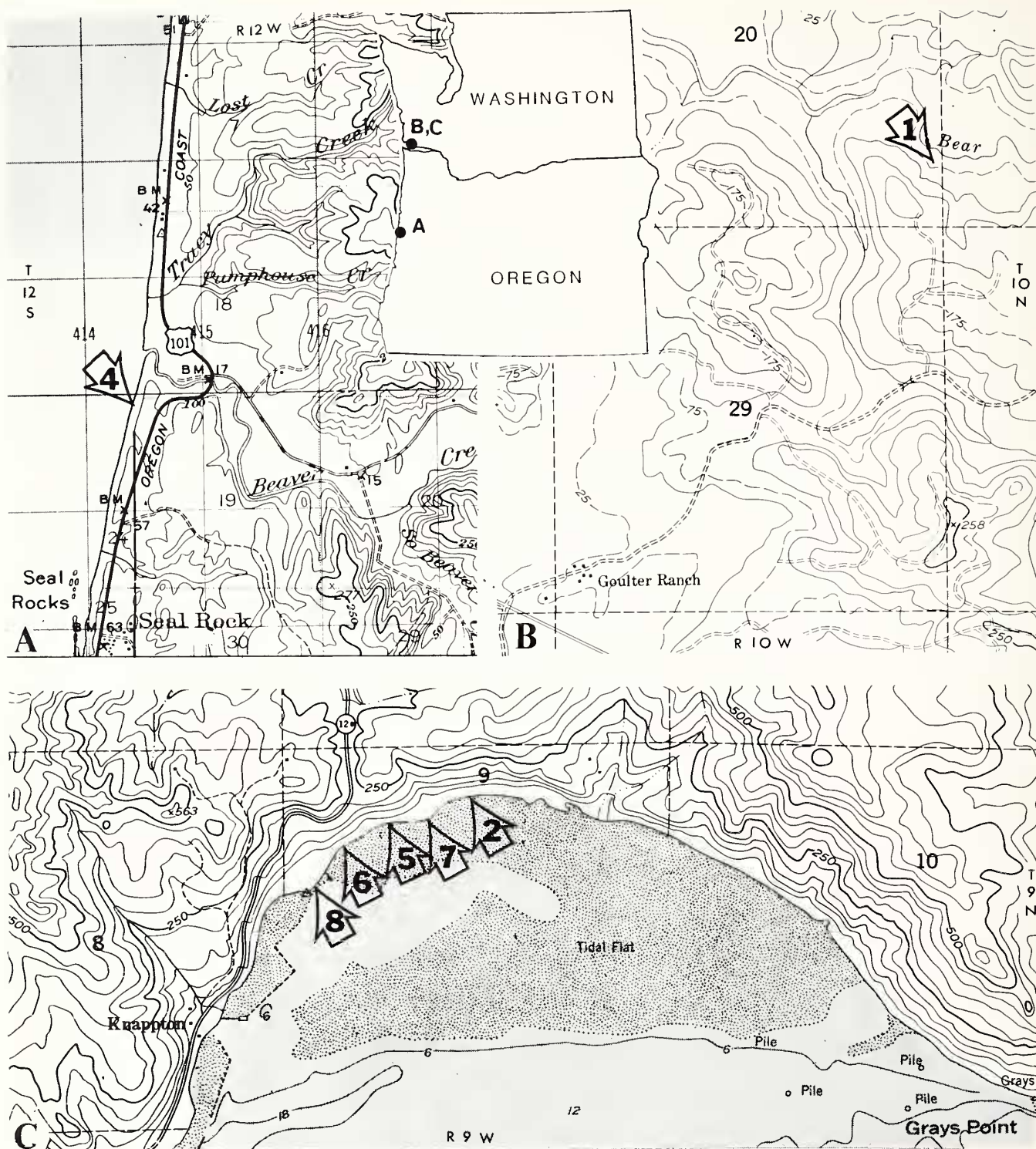


Figure 1. Index maps to sponge localities in southwestern Washington and northwestern Oregon. Arrows indicate collecting localities. A, Ona Beach locality (4, LACMIP 6148) south of Newport and north of Seal Rocks on the coast, Yaquina 15-minute quadrangle, Lincoln County, Oregon. B, Bear River locality where calcified sponges and mollusks occur in "reefoidal" limestone (1, LACMIP 5802), Chinook 7½-minute quadrangle, Pacific County, Washington. C, Knappton localities in the Lincoln Creek Formation where it is exposed in the sea cliff, (8, LACMIP 5787, Oligocene; 2, LACMIP 5842, Upper Oligocene; 5, LACMIP 5843, Lower Oligocene; 6, LACMIP 5844, Eocene; 7, LACMIP 5852, Oligocene) on the north shore of the mouth of the Columbia River, Knappton 7½-minute quadrangle, Pacific County, Washington.

Foraminiferal Stages		Molluscan Stages	WASHINGTON		OREGON	
			Knappton Area	Bear River Area	Seal Rocks Area	
Miocene	Saucesian	Newportian	Astoria (?) Formation		Astoria (?) Formation	
		Pillarian	?		Nye Mudstone	
Oligocene	Zemorrian	Juanian	Unit 4 5842	5787	Yaquina Formation 6148	
			Unit 3 5852			
		Matlockian	Unit 2 5843		Lincoln Creek Formation	Alsea Formation
			Unit 1 5844			
Upper Eocene	Refugian	Galvinian	?		Siltstone of Cliff Point 5802	

Figure 2. Stratigraphic distribution of localities in the Knappton, Bear River, and Yaquina (Seal Rocks) areas showing relationships of the informal units of James and Gail Goedert, Natural History Museum of Los Angeles County localities, and biostratigraphic zones of the Tertiary section (modified from Zullo, 1982; Wells, 1979; Snively and others, 1975; Armentrout, 1981; Rau, 1981).

to latest Oligocene (Rau, 1958, 1964, 1981; Armentrout, 1975, 1977, 1981).

James L. Goedert (Zullo, 1982:2-3) has subdivided the Lincoln Creek beds in the Knappton outcrops into four informal units (Figure 2). Unit 1 is a barnacle-bearing concretionary unit associated with the abundant U-shaped trace fossil, *Tisoo*. Unit 2 is characterized by sponges, small aturiid nautiloids, many decapod crustaceans, and marine vertebrate remains associated with troid burrows. Unit 3 is characterized by a glass sponge fauna and Unit 4 by an abundance of marine vertebrate and invertebrate fossils, but few sponges. Zullo (1982:2-3, fig. 2) concluded that lower Unit 1 is Upper Eocene, Unit 2 is Lower Oligocene, and Units 3 and 4 are Upper Oligocene (Figure 2).

The sponges noted here from Oregon are reportedly from the Astoria Formation at the type locality in Astoria and from the Yaquina Formation near Seal Rocks. Moore (1963) described outcrops and faunas of Astoria beds in the type area and southward along the Oregon coast for approximately 70 miles. One specimen of *Aphrocallistes* has been figured from the type area of the Astoria Formation by Moore (1963, pl. 32, fig. 16), but the precise locality from which the early collection was made is uncertain. No additional sponges have been reported from other exposures along the sea cliff between Astoria and Newport. However, a few sponges have

been recovered from the Yaquina Formation south of Newport, in the Seal Rocks area (Figure 1).

Moore (1963:12) described Astoria beds in the coastal area as mainly marine silty shale and fine-grained sandstone, with interbedded siltstone, coarse-grained sandstone, conglomerate, and tuff. She reported that concretions up to a foot and a half in diameter are common in some places. Such concretions have produced nearly all the sponges from the Astoria, Yaquina, and Lincoln Creek localities. Some concretions contain a varied molluscan fauna, fragments of carbonized wood, many with teredinid borings, marine mammal bones, fish bones and scales, a varied foraminiferal fauna, decapod crustaceans, and barnacle fragments. Many concretions are coarse-grained glauconitic sandstone that shows evidence of vigorous transport. These assemblages may have been mixed, that is may have been derived from a variety of depositional sites, by downslope movement.

The sponges, in general, are delicate and silicified and can be freed from the calcareous matrix. Some concretions were partially etched in dilute acetic acid and screened for recovery of all microorganisms. In general, the concretions are highly argillaceous, often sandy and glauconitic. For complete removal of matrix, the partially etched calcareous muds were gently brushed and washed from the sponge material. Some fine cleaning of specimens was done with a microsandrblaster

air-abrasive unit. Some delicate etched specimens were hardened in weak acetone-soluble plastic solutions.

LOCALITIES

The fossil sponges described here were all collected by James L. and Gail H. Goedert, except for the sponge reported by Ellen J. Moore (1963:89, pl. 32, fig. 16), and are deposited in the Natural History Museum of Los Angeles County, Invertebrate Paleontology Section (abbreviated LACMIP).

LOCALITY 1. Limestone in the siltstone of Cliff Point of Wells (1979) in a quarry in the bluff on the south side of Bear River, 2.2 km (1.4 miles) northeast of Goulter Ranch, on the section line between Sections 20 and 21, T. 10 N., R. 10 W., on the Chinook 7½-minute quadrangle, Pacific County, Washington. LACMIP locality 5802, Upper Eocene.

LOCALITY 2. Lincoln Creek Formation in association with other invertebrate fossils, mammal and fish bones, and plant fragments in calcareous, argillaceous concretions that range from fine-grained to coarsely clastic, from a landslide area at the head of the bay between Knappton and Grays Point in the center N ½ N ½ of Sec. 9, T. 9 N., R. 9 W., on the Knappton 7½-minute quadrangle in Pacific County, Washington. The locality is approximately 1.6 km (1 mile) northeast of Knappton. LACMIP Locality 5842, Upper Oligocene.

LOCALITY 3. Astoria Formation at Astoria, as cited by Moore (1963:90) at her locality 1a, from collections of James D. Dana discussed by Dall (1909:140), Miocene.

LOCALITY 4. Sponges from the Yaquina Formation, in fossiliferous concretions from rocks exposed at Ona Beach, 0.4 km (0.25 mile) south of the mouth of Beaver Creek, west of U.S. Highway 101, 2 km (1.3 miles) north of the community of Seal Rocks, just west of the northwest corner of Sec. 19, T. 12 S., R. 11 W., Lincoln County, Oregon, Yaquina 15-minute quadrangle. LACMIP Locality 6148, Miocene.

LOCALITY 5. Lower Oligocene part of the Lincoln Creek Formation, from concretions weathering out of the sea cliff in the northwestern part of the bay between Grays Point and Knappton, approximately 305 m (1000 feet) south and 430 m (1400 feet) east of the northwest corner of Sec. 9, T. 9 N., R. 9 W., on the Knappton 7½-minute quadrangle, in Pacific County, Washington. The locality is approximately 300 m (1000 feet) west of Locality 2, and 300 m (1000 feet) northeast of Locality 7. LACMIP Locality 5843, Lower Oligocene.

LOCALITY 6. Upper Eocene part of the Lincoln Creek

Formation, concretions weathering out of the sea cliff in the western part of the bay between Grays Point and Knappton, approximately 0.8 km (0.5 mile) northeast of Knappton; 122 m (400 feet) east and 520 m (1700 feet) south of the northwest corner of Sec. 9, T. 9 N., R. 9 W., on the Knappton 7½-minute quadrangle, Pacific County, Washington. LACMIP Locality 5844, Upper Eocene.

LOCALITY 7. Oligocene part of the Lincoln Creek Formation, collected from the "sponge zone" in concretions weathering out of the sea cliff, approximately 1.3 km (0.8 mile) northeast of Knappton, 305 m (1000 feet) south and 580 m (1900 feet) east of the northwest corner of Sec. 9, T. 9 N., R. 9 W., Knappton 7½-minute quadrangle, Pacific County, Washington. This is the most productive sponge locality of those cited here. LACMIP Locality 5852, Oligocene.

LOCALITY 8. Lincoln Creek Formation on the Columbia River, approximately 122 m (400 feet) east of the boundary between Sections 8 and 9, T. 9 N., R. 9 W., approximately 0.8 km (0.5 mile) northeast of Knappton, Knappton 7½-minute quadrangle, Pacific County, Washington. A general Knappton locality of older collections before units were established. LACMIP Locality 5787, Oligocene.

SYSTEMATICS

Class Hexactinellida Schmidt, 1870

Order Hexactinosa Schrammen, 1903

Suborder Scopularia F. E. Schulze, 1885

Family Aphrocallistidae Gray, 1867

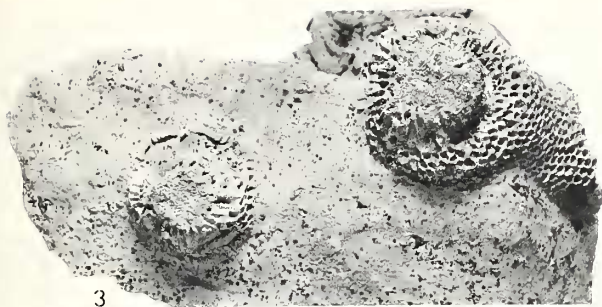
Genus *Aphrocallistes* Gray, 1858

Aphrocallistes polytretos n. sp.

Figures 3–10, 13–17, 21

DIAGNOSIS. Branching tubular to cuplike or irregular undulating leaf- or ear-shaped sponges with upper walls perforated by honeycomblake, subprismatic to polygonal primary canals in full diarthysis and open on both sides of the wall. Basal attachment and lower part of walls irregularly dictyonine with fewer canals. Each canal of upper wall outlined by a complex net of siliceous skeletal strands produced by hexiradiate beams whose rays have been distorted to be more or less in the plane of the porous canal walls. No sculp-

Figures 3 through 10. *Aphrocallistes polytretos* n. sp. (3) Basal view of two specimens showing dense irregular attachment areas grading up into distal radially canalled area. Paratype, LACMIP 6601, Locality 2, ×1. (4) Natural vertical section through an irregularly dictyonine base and associated lower canalled area. Definition of canals increases away from base, along with increase in modification of spicule structure toward hexiradiates. Paratype, LACMIP 6602, Locality 8, ×2. (5) Side view of well-preserved paratype with honeycomblake wall and tubular to cuplike form but with broken upper end. Base of this same specimen is shown in upper right of Figure 3. LACMIP 6601, Locality 2, ×2. (6) Fragments of sponge showing coarse conglomeratic and glauconitic nature of common matrix. LACMIP 6603, Locality 7, ×1. (7) Side view of broad flattened, moderately fine-textured paratype. LACMIP 6604, Locality 7, ×1. (8) Side view of holotype showing annular tubular form and honeycombed walls. Reverse side has concave-up, dictyonine-spiculed diaphragmlike interruptions that probably marked pulses in growth. LACMIP 6600, Locality 2, ×1. (9, 10) Stereoscopic photomicrographs of skeletal net of the holotype showing canal patterns, shape, and hexiradiate skeleton typical of the middle and distal part of the sponge. LACMIP 6600, Locality 2, ×5.



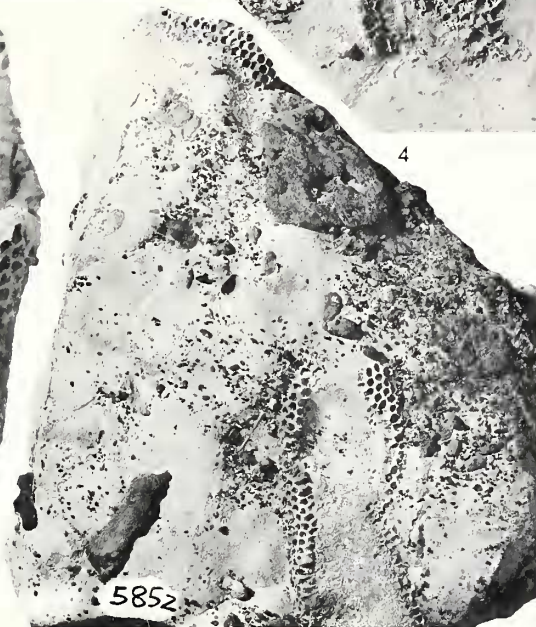
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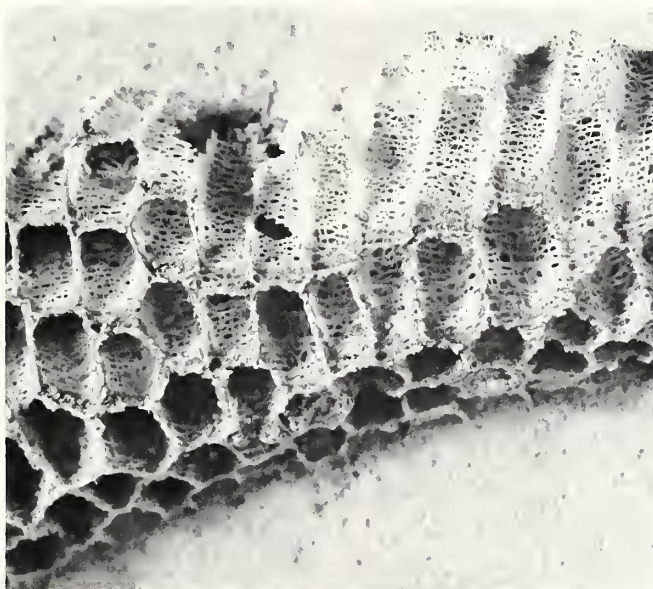
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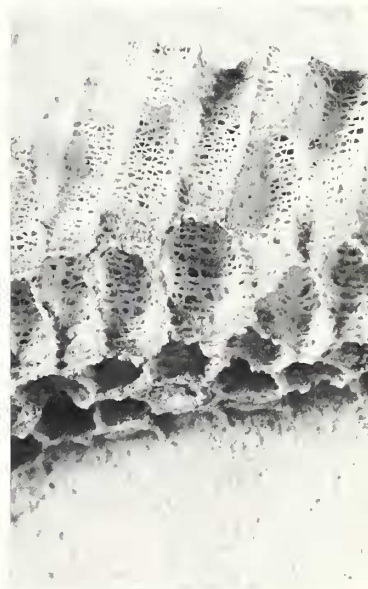
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ture is evident, except for the undulating surfaces. Polygonal canals are generally 1.0–1.5 mm across in a wall 2–5 mm thick. Upper part of skeleton of irregular flattened hexiradiate dictyonial beams with largest, earliest formed beams essentially horizontal but connected with irregularly diagonal and vertical strands in a cross-bracing crudely hexiradiate pattern, like an expanded metal screen, with roughly hexagonal openings often subdivided into triangular sections. All beams fused into a solid network; each is minutely spinose.

Canals much larger and less oblique, and skeleton in mature parts much more hexiradiate-dominated and much less clearly dictyonine, than in *Aphrocallistes vastus whiteavesianus* Lambe and *A. vastus vastus* Schulze. Canals much larger but more closely spaced and more commonly prismatic than in *A. alveolites* Roemer and *A. cylindrodactylus* Schrammen.

DESCRIPTION. Numerous nearly complete siliceous fragments to broken bits of the sponge occur, often as several pieces with different growth forms in single concretions. The holotype is a subtubular undulating sponge with a diameter of 30–35 mm. It is approximately 80 mm tall and is subdivided into three subequal sections with saucer-shaped, noncanalled partitions with a texture like that of bases on other specimens.

The wall expands upward from a thickness of 2.0–2.5 mm in the lower part of the fragment, to 2.5–3.5 mm in the middle segment, and to a maximum of 4.0–4.5 mm at the upper end of the fragment. The arcuate saucer-shaped noncellular partitions are generally 0.5–1.0 mm thick in the center of the tubular opening. The lower segment is approximately 15 mm high, the middle segment is 20 mm high, and the uppermost is 20 mm high, above the uppermost cellular separation. Other fragments show the same range in wall thickness, although most are only undulating irregular platelike bits or tube sections. Some nearly complete cup-shaped sponges show the massive base, a few millimeters across, and a tubular form 8–30 mm in diameter and up to 90 mm long or high.

Individual canals pierce the walls, essentially normally, in full diarthysis. They are 1.0–1.8 mm across on the outside but are only 0.8–1.5 mm across on the inside, showing expansion of the canals related to their radial orientation. They are closely packed, although not in predictable horizontal or vertical series, and are so spaced that 7–8 occur in 10 mm, both horizontally and vertically on the exterior. Many of the canals have rectangular cross sections, but with rounded mar-

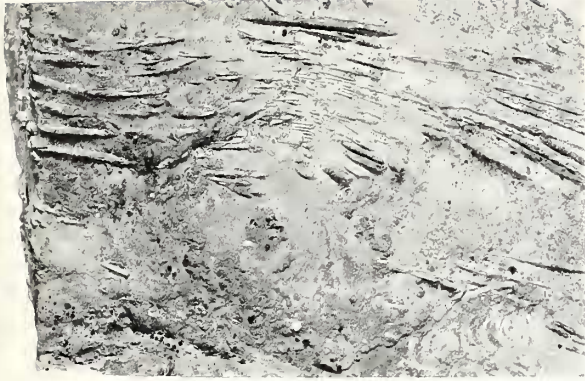
gins. Hexagonal and pentagonal openings also occur, commonly in the middle unmodified parts of the segments. All canals have porous walls so that there could have been complete interconnection with adjacent ones. Canal walls are perforated at irregular intervals with distinct rounded openings 0.10–0.22 mm across. These are less common than the much smaller and more irregularly sized triangular openings that occur between the diagonal and vertical beams in the hexiradiate-based skeletal net.

The skeleton is composed of fused solid beams that are difficult to separate into single spicular elements. Walls are principally outlined by horizontal fibers that tend to bifurcate horizontally at the wall intersections and vertically in the middle part of the wall. These are the first beams secreted at any level in the skeleton and are the most massive units. They are spaced 5–7 horizontal beams per mm, measured vertically along the canal wall. Most of these strands are 0.06–0.08 mm across, but in some areas where the skeletal net is dense, they have been thickened to 0.10–0.12 mm in diameter. These dominantly horizontal units are crossbraced by diagonal and vertical units in the basic flattened hexiradiate skeleton. Diagonal beams are next to horizontal ones in size and are generally 0.03–0.06 mm across. Vertical beams are apparently the last added and are the smallest, ranging from tiny hairlike spines 0.01 mm across up to rods 0.04–0.05 mm in diameter, fused at both ends. Diagonal beams are less continuous than horizontal ones, and vertical ones are the least continuous. However, vertical beams can be traced completely along the canal wall, in some areas, parallel to the trend of the canals.

Most skeletal elements are shared between two adjacent canals in the thin wall. Elsewhere, particularly in proximal parts of the sponge, double walls occur, with each canal having its own subparallel fused series of elements. These strands bifurcate to produce triangular or polygonal radial openings along the common juncture between three or four adjacent canals.

Beams are apparently solid and appear to have been built by enlargement, with layered secretions over initial small needles or spines. These needles are common in young parts of the skeleton, pointing upward and horizontally from adjacent thicker strands. Some beams are so enlarged that they combine to produce a nearly solid fused wall in the older parts of the net. Exchange between canals is moderately limited in these areas, but in the outer, more open-textured parts,

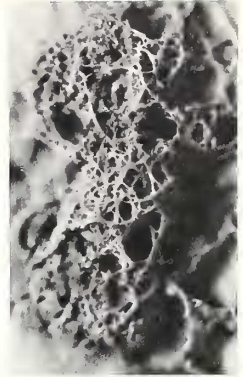
Figures 11 through 17. Root tufts and *Aphrocallistes polytretos* n. sp. **Figures 11, 12.** Root tufts. **(11)** Large concretion with aligned oxeate root tuft spicules in fine-grained calcareous siltstone, which has undergone some bioturbation (lower right). LACMIP 6611, Locality 7, $\times 1$. **(12)** Large monaxial root tuft spicules in fine-grained siltstone showing packing, shape, and general preservation that indicate they have not been moved after formation of the tuft. LACMIP 6612, Locality 5, $\times 2$. **Figures 13 through 17.** *Aphrocallistes polytretos* n. sp. **(13)** Photomicrograph showing irregular spicules of basal attachment and dense, noncanalled pattern, in left center of Figure 17. LACMIP 6605, Locality 5, $\times 10$. **(14)** Part of a concretion containing *Aphrocallistes* with irregular branching growth form in variously colored fine-grained matrix, which produces blotchy appearance. Paratype, LACMIP 6606, Locality 2, $\times 1$. **(15)** Photomicrograph of lower part of sponge showing thick canal walls and change from dictyonine-based skeleton in lower right to hexiradiate skeleton in upper left. Side of same specimen in Figure 4. Paratype, LACMIP 6602, Locality 8, $\times 10$. **(16)** Photomicrograph of dictyonine part of basal skeleton of paratype illustrated in Figure 4, in left center, but rotated 90 degrees. Somewhat swollen spicule nodes and irregular fabric are characteristic. LACMIP 6602, Locality 2, $\times 10$. **(17)** Irregular basal region and part of honeycomblike tubular wall of paratype. Base shown enlarged in Figure 13. LACMIP 6605, Locality 2, $\times 2$.



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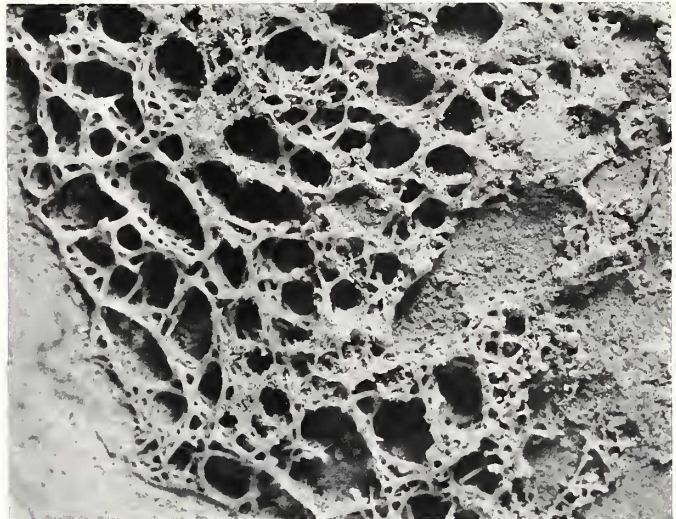
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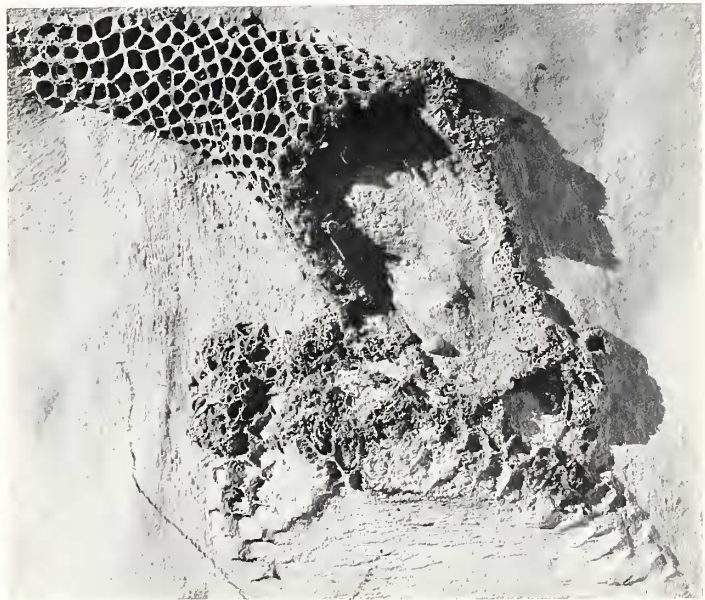
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interchange could have been effected, even through double walls where two skeletal layers separate adjacent canals.

The entire surface of each spicular strand, particularly the thickened ones, is covered by minute conical spines 0.005–0.01 mm high and across. Some tiny elements extend as fine needles from small conical bases. These cones and spines are generally 0.01–0.02 mm apart and appear to be scattered irregularly over the entire surface of the major strands.

DISCUSSION. Generic and family placement of these sponges is based on their peculiar flattened hexactine hexiradiate skeleton. The sponges superficially appear like lithistids, composed of orchoclad dendroclones. The “clads” are fused to “clads” of other spicules to produce a flattened roughly hexagonal series of openings with one spicule axis essentially normal to the long dimensions or axes of the canals, but individual lithistid spicules cannot be identified.

The large canals might be considered as peculiar porous calicles, such as in the sclerosponge *Merlia* or the chaetaetids. However, in sclerosponges, the calicles rise from an imperforate base rather than forming perforate walls around a subcylindrical or platelike porous sponge.

Schrammen (1912:358), in a summary table of stratigraphic ranges of Cretaceous fossils of northwestern Germany, noted that *Aphrocallistes* ranges from the Late Cretaceous into Recent. He also listed the genus from Tertiary rocks of Russia, Japan, and Oran, but cited no references for those occurrences. Schrammen (1912:219–222) differentiated three species of the genus on general body shape, wall thickness, presence or absence of terminal sieve plates, or whether the forms are many branched or relatively simple structures. In general, the German species have canals considerably more widely separated and distinctly smaller than our specimens.

Schrammen (1912:185) summarized the observed depth ranges of living species of *Aphrocallistes*. In general, their range is from approximately 100–1700 m. Reid (1968:549) cited occurrences of *A. vastus* as shallow as 27.5 m from Puget Sound. He also listed other occurrences off Oregon and Washington in water 97 and 108 m deep. Living species described by Schulze (1887) occur essentially in the North Pacific, from localities in the Philippine Islands, Japan, the Aleutian Islands, and along the coast of Oregon and Washington, California, and Vancouver Island. Thus, it is not surprising to find *Aphrocallistes* in Eocene to Miocene beds in Oregon and Washington.

Aphrocallistes was collected from Astoria beds at Astoria, Oregon, on the south bank of the Columbia River (Dana,

1849). That specimen was noted by Dall (1909:140) and figured by Moore (1963, pl. 32, fig. 16) as an unidentified ophiuroid (?) as an incidental occurrence to her extensive treatment of the Miocene mollusks from the Astoria Formation of Oregon.

Canal patterns in living *Aphrocallistes vastus whiteavesianus* Lambe, illustrated by Reid (1964, text-fig. 47), and *Aphrocallistes vastus vastus* Schulze show markedly oblique canals and clearly defined dictyonine-based skeletons in a moderately rectangular arrangement. Development of hexiradiate patterns is more clearly shown in *Aphrocallistes beatrix* Gray, as figured by Reid (1964, text-fig. 49b). Even in that species, however, there is a moderately oblique orientation to some canals in the gastral region, and wall thicknesses tend to be somewhat greater than in the Tertiary species from Washington and Oregon. Canal dimensions in each of these are considerably smaller than in the fossil *A. polytretos*. There is striking similarity of skeletal arrangements in *A. beatrix* to that of the Tertiary fossils. The walls are somewhat thicker in the Recent species, and the canals tend to be more circular than distinctly prismatic, such as in the fossil forms. Such rounded canals are the general pattern, as well, in the Cretaceous sponges described by Schrammen (1912:219–222). *A. polytretos* is similar to *Aphrocallistes beatrix* in having the dictyonine strands obscure, in contrast to *Aphrocallistes vastus* varieties.

Aphrocallistes beatrix Gray (1858:114–115) was described from the Azores in the Atlantic Ocean. Some of the limited modern distribution is unquestionably related to sampling difficulty and spacing of samples in the 100–1000 m range in the modern oceans.

Associated benthonic foraminifers and mollusks, including the nautiloid *Aturia*, suggest water depths between 300 and 600 m, which is also within the range of modern *Aphrocallistes*. The assemblage may have been transported from moderately shallow waters of 300–400 m and accumulated ultimately in depths as great as 2000–4000 m.

Specific characteristics are the size of individual canals and skeletal elements and the general growth form of the sponges.

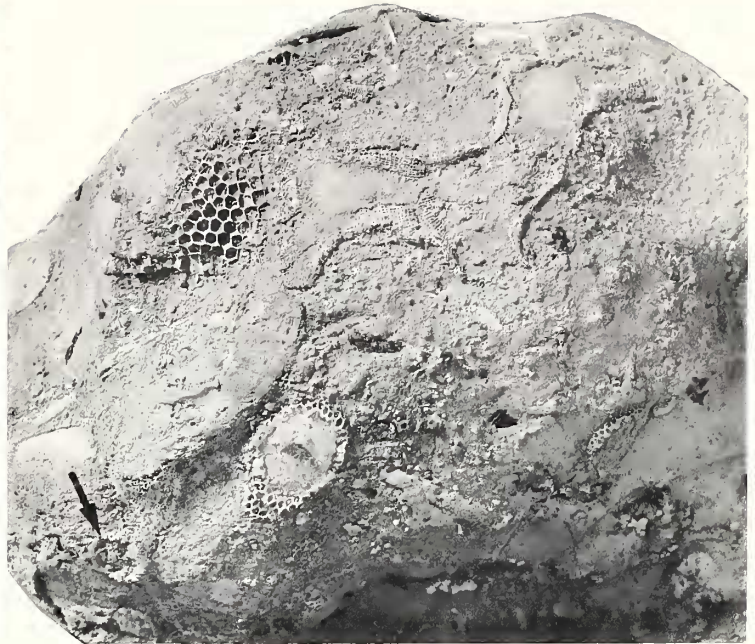
Our species is fairly variable and ranges at least from Late Eocene to Miocene. These Tertiary sponges show a general increase in canal size, a decrease in canal wall thickness, and a tendency for a more prismatic canal pattern, when compared to the Cretaceous species from northwestern Germany.

Schrammen (1912:220) noted a terminal or oscular sieve-like diaphragm on branches of *A. alveolites* Roemer and *A.*

Figures 18 through 22. *Eurete goederti* n. sp. and *Aphrocallistes polytretos* n. sp. **Figures 18 through 20 and 22.** Holotype of *Eurete goederti* n. sp. LACMIP 6609, Locality 7. (18) Photomicrograph of gastral part of dictyonine skeletal net showing marked regularity of enlarged strands and somewhat smaller cross-connecting beams. Spicule nodes are little swollen. Figure 23 is a drawing of part of the net in the upper left. $\times 5$. (19) Holotype of *Eurete goederti* and associated fragments of *Aphrocallistes* in bioclastic matrix of a concretion from Locality 7. The regularly spaced zigzag pattern of the branching sponge is clearly shown. Proximal is to upper right and distal to lower left, where circular cross section shows near shadowed boundary (arrow). $\times 1$. (20) Photomicrograph of thin walls of the holotype, with diverging walls that are 3 or 4 spicule complexes thick. Gastral surface is to the right. $\times 5$. (22) Well-preserved part of the skeleton showing thickness of the walls in lower part and regular nature of skeleton in middle and upper part. Parts of three dichotomous branches, producing zigzag structure of the sponge, are shown. $\times 3$. **Figure 21.** *Aphrocallistes polytretos* n. sp., paratype illustrated in Figure 17, here enlarged to show smaller hexactine-based spicules partially filling canals. LACMIP 6605, Locality 2, $\times 15$.



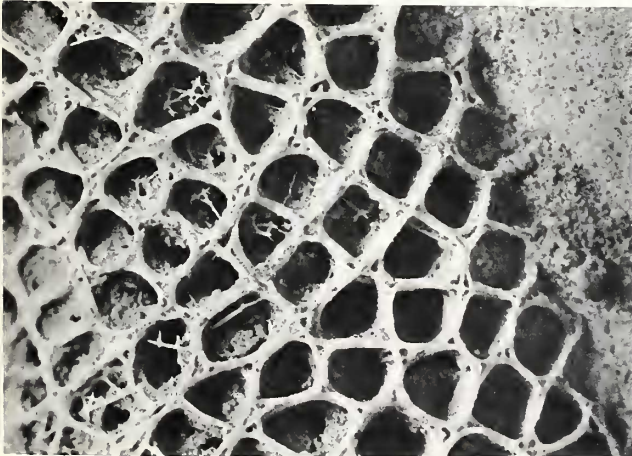
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22

cylindrodactylus Schrammen. Diaphragms are present in the Washington Oligocene specimens, but in general these are concave-up divisions within tubular parts of the sponge and must mark pulses in growth of the sponge rather than convex-up terminations like those on the German Cretaceous sponges. Orientation in the Tertiary sponges is well defined by development of irregular basal areas, just as the terminations are well defined in Schrammen's *A. cylindrodactylus* by the rounded fingerlike growth.

TYPE SPECIMENS AND AVAILABLE MATERIAL. Holotype LACMIP 6600 from Locality 7, the type locality of the species, and paratypes LACMIP 6601, 6603, 6607, 6608 from Locality 7, LACMIP 6605, 6606 from Locality 5, LACMIP 6604 from Locality 7, LACMIP 6602 from Locality 8. In addition 22 specimens or concretions were obtained from Locality 1, 18 from 2, 1 from 4, 1 from 5, 2 from 6, and 12 from Locality 7. Some concretions contain several specimens or fragments.

ETYMOLOGY. *Poly*, Gr., many; *tretos*, perforated, referring to the many coarse canals through the cellular-appearing wall.

Family Euretidae Zittel, 1877
(*vide* Schulze, 1887)

Subfamily Euretinae Reid, 1958

Genus *Eurete* Semper, 1868

Eurete goederti n. sp.

Figures 18–20, 22, 23

DIAGNOSIS. Dendroid or irregular zigzag heterotomously branching axial tube with short lateral branches, both approximately 8–10 mm in diameter; branches approximately 20 mm apart. Walls 0.5–1.1 mm thick; skeletal net eurentoid, lacking prominent ostia and postica; moderately open skeleton lacking well-defined gastral and dermal cortex; strands originate on gastral surface and parallel that surface before arching steeply through the wall. Gastral strands approximately 0.10–0.23 mm apart and 0.10 mm in diameter, with nodes 0.16–0.18 mm in diameter spaced 0.4–0.5 mm apart along strands and cross connected by beams 0.06–0.09 mm across to form rectangular meshes. Nodes slightly to distinctly swollen but not spherical.

Branches more closely and regularly spaced and slightly larger than in *E. lithodendron* Reid, and much better developed than closely spaced, rudimentary branches in *E. (?) setosum* Reid. Lacks cortex and ostia that are developed in both *E. lithodendron* and *E. (?) setosum*. Growth form and branches more regular than in *E. schmidtii treubi* Ijima. Spherical nodes absent at spicule centra, although common in related species.

DESCRIPTION. Several fragments are in the collection. The most complete, the holotype, is a fragment approximately 12 cm high. It is an elongated branched form in which the axial tube has undergone heterotomous division to produce a dichotomous structure in which one of the two branches ceases to grow and the other grows to divide again. This

produces a zigzag growth pattern with angles of approximately 120–130 degrees between segments of the axial tube. The axial tubes and branches are 8–10.5 mm in diameter. The short lateral branches are spaced approximately 20 mm apart along the axial tube and are approximately 1 cm long. Oscula occur at the ends of the lateral rudimentary branches and range from openings to somewhat constricted.

Walls of tubes and branches are 0.5–1.1 mm thick and have a generally thin, but well-defined gastral layer of thickened strands and beams. Most of the wall is composed of relatively open-textured endosomal skeleton. A dermal layer is not differentiated in the well-developed dictyonal framework. The thickened gastral layer usually affects only strands and beams at the immediate gastral surface.

Neither ostia nor postica are clearly defined, although some irregular interruptions in the outer part of the skeleton may represent ostia. These are subcircular openings, 0.15–0.3 mm across, and are irregularly developed in the visible exterior. No similar interruptions are evident in the inner part of the skeleton, and water must have passed through the wall via the open skeletal meshes.

Strands of the dictyonal skeleton originate near or at the gastral surface and parallel that surface before swinging abruptly dermally. They terminate as unattached conical to spinelike rays at the outer margin of the wall, where they are often nearly at right angles to the dermal surface. In the gastral layer, strands are parallel and spaced 0.15–0.4 mm apart. They are closest immediately distal to insertion of a new strand, often by “branching,” and are farthest apart immediately proximal to the insertion. Spicular nodes are spaced by beams 0.4–0.5 mm long along the gastral strands and are connected laterally by beams 0.10–0.25 mm long, measured horizontally on the gastral surface. Beams of gastral strands are 0.08–0.11 mm in diameter midway between nodes, with most 0.10 mm across. Lateral gastral beams are 0.06–0.09 mm across, with most in the upper end of that range. Nodes are 0.10–0.22 mm in diameter but without much swelling other than slight flaring where rays meet. Nodes throughout the skeleton are not spherical but appear almost rectangular. Most such nodes are 0.16–0.18 mm across in the endosomal part of the wall.

Endosomal and dermal beams are slightly smaller than gastral ones, with common diameters of 0.06–0.10 mm and lengths of 0.2–0.3 mm, thus spacing nodes three-dimensionally that distance within the wall. This part of the wall is less linearly organized than the gastral part and is 2–4 spicules thick. Free beams form only low rounded knobs or cones on the gastral surface but pointed spines on the dermal surface.

Skeletal mesh openings are generally rectangular in the inner part of the skeleton but become much more irregular and commonly triangular in the middle and outer part of the wall.

Adnate small free hexactines occur commonly throughout the skeleton. They are generally attached to a beam by one ray, and the other rays of the tiny spicules are free. They range from small spicules with rays only 0.15 mm long and 0.005 mm in diameter up to larger forms with rays 0.3 mm

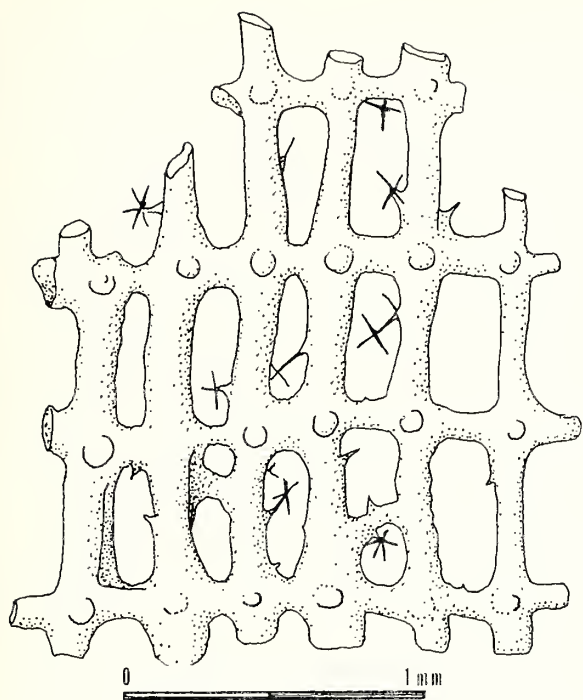


Figure 23. *Eurete goederti* n. sp., drawing of part of the skeleton of the holotype showing smaller attached hexactines and larger beams of gastral dictyonine net. Vertical strands are dominant elements in this part of the net. Distal is toward the top, and proximal is toward the base. LACMIP 6609, Locality 7, approximately $\times 40$.

long and 0.008–0.010 mm across in basal ray diameter. They are frequently oriented with rays parallel to the major dictyonal elements, in the general plane of those elements, or at approximately 45 degrees to those elements where they project out into the “cubic” meshes (Figure 23). Beams in the skeleton all show granular to distinctly spinose surfaces, many of the tiny spines only 0.005 mm across and 0.10 mm or less high.

DISCUSSION. *Eurete goederti* n. sp. is most similar to Cretaceous *E. lithodendron* Reid (1961:34–38, pl. 7, figs. 4a, b) in general growth form but is slightly larger. In addition, branching is more distant in *E. goederti* n. sp., and it lacks a dermal cortex and ostia, which are present in *E. lithodendron*. Modern *E. schmidtii treubi* Ijima (1927:170; Reid, 1961:37, fig. 2a) also has a similar growth form but branches considerably more irregularly.

E. (?) setosum Reid (1958:38–40), from the Cretaceous of Great Britain, is also a tubular branching form, but its branches are often reduced to rudimentary structures, in contrast to the distinct branches in *E. goederti*. In addition *E. (?) setosum* has a dermal cortex and ostia in places, and branches are spaced relatively closely together. Branching in *E. goederti* is considerably more regular than in either *E. lithodendron* Reid, *E. (?) setosum* Reid, or in the living *E. schmidtii treubi*. The northwestern United States fossil species also lacks spherical spicule nodes that are common in the other species.

Depth ranges of living species of *Eurete* were summarized

by Schrammen (1912:184–185), based upon work by Schulze and Carter. Shallowest occurrence cited by Schrammen is 220 m for *Eurete carteri* Schulze, and deepest is 717 m for *E. erectum* Schulze. Most species are listed from depths of 300 or 360 meters. Reid (1968:549) listed *Aphrocallistes vastus* Schulze as having been collected in depths of 27.5 m (Puget Sound), 97 m (Oregon), and 108 m (Vancouver, British Columbia) but noted that the Puget Sound site is the shallowest authenticated record of modern dictyonine hexactinellids. By analogy it seems likely that the Washington Oligocene species had a depth range of 100–350 m. The fragmental nature of our material, however, suggests that the assemblage may have been transported. Downslope transport is suggested by occurrence of these and associated fossils in thin, coarse, sandy to glauconitic beds, intercalated as high-energy pulses in the dominantly fine-grained sequence.

TYPE SPECIMENS AND AVAILABLE MATERIAL.

The holotype, LACMIP 6609, is the largest fragment and occurs with *Aphrocallistes* fragments, pieces of wood, fish fragments, and foraminifers in a coarse sandy siltstone from Locality 7, the type locality of the sponge species. The paratype (LACMIP 6610) and an additional, more fragmental piece of *Eurete* are also from the same locality. One concretion from Locality 8 also contains tiny scraps of dictyonian skeleton that are probably from *E. goederti*; these are too small to determine growth habit and other relationships but have the same proportions in the gastral net as the holotype of *E. goederti*.

ETYMOLOGY. *Goederti*, named for James Goedert, on whose collections this and parallel studies of other groups are largely based.

Order, Family, Genus Uncertain

Hexactinellid Root Tufts

Figures 11, 12

Several concretions contain moderately well organized root tufts of hexactinellid sponges. These are composed of concentrically layered, aligned, large, doubly tapering oxas (?), with maximum diameters of 1.1–1.4 mm at approximately midlength. Neither entire length nor preserved tips were observed on any single spicule, but spicule fragments at least 3 or 4 cm long occur in fine-grained calcareous siltstone where sharp tips and double taper are well shown. They form clusters 3 or 4 cm across and are commonly isolated from other sponges. In one small concretion from Locality 2, isolated large root tuft spicules occur embedded in irregular basal spicular masses of *Aphrocallistes*. Bases of other specimens of the species do not have such spicules and apparently were cemented to bivalve or gastropod fragments or pebbles. This implies that the tuft spicules are not an integral part of *Aphrocallistes* but that the sponge from Locality 2 overgrew exposed root tuft spicules, which formed a solid substrate “island” on the muddy bottom. Concretions, without *Aphrocallistes*, from the same locality contain both root tuft clusters and fragments of *Eurete*, but the sponge fragments and root spicules are not intergrown and may be unrelated biologically. The root tufts may represent sponges not otherwise

preserved in the collections. Taxonomic relationships of root tufts are unknown.

FIGURED SPECIMENS AND AVAILABLE MATERIAL. Figured specimen LACMIP 6612 is from Locality 5, and 6611 is from Locality 7. Five other concretions containing tuft fragments were collected from Locality 2, and one was collected from Locality 5.

Similar root tufts of large bundled oxcas, which show concentric layering, occur at two other localities (Armentrout, personal communication, 1982). One such tuft was collected by Susan Bee, from Portland State University, from Late Eocene siltstone of the upper member of the Keasey Formation. The fossil was float in a 5-m high railroad cut south of and upslope from the abandoned railroad trestle across Highway 47, between Buxton and Vernonia, approximately 20 m (80 feet) west and 210 m (700 feet) north of the southeast corner of Sec. 8, T. 3 N., R. 4 W., on the Vernonia 7½-minute quadrangle, Washington County, Oregon (Locality Tok-M112 of Warren and others, 1945).

The other tuft was collected from Late Eocene siltstone of the Lincoln Creek Formation by J.M. Armentrout. It came from the upper 3-m (10-foot) interval at the top of a cliff on the south side of Canyon River, just upstream from a logging road bridge, approximately 240 m (800 feet) west and 67 m (220 feet) north of the southeast corner of Sec. 13, T. 21 N., R. 6 W., on the Grisdale 15-minute quadrangle, Grays Harbor County, Washington (Locality CR9 and 10 of Armentrout, 1973).

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